Quarterly EOS Contract Report - Report #45

Period: July 1 - September 30, 1995

Remote Sensing Group (RSG), Optical Sciences Center at the University of Arizona

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Contract Number: NAS5-31717

Report compiled by: K. Thome

Summary:
Work by members of the RSG during the past quarter consisted of Science Team support activities including the attendance at meetings related to MODIS, work on the atmospheric correction of ASTER data, and assisting in a stray light study for MODIS. Significant progress was made on the SWIR CCR with measurements of reflectance of possible interior paints, characterizing our Optronic monochromator for filter measurements, development and initial fabrication of mechanical parts of the system, and work with the system's lock-in amplifier. We continued improvements to our calibration facilities and blacklab including characterizing humidity effects in our calibration laboratory. Preliminary results were obtained from a cross-calibration study of HRV and TM and we developed the capability to process our field data for hyperspectral sensors. Field work activities were continued with trip planning for an October trip to White Sands and work to upgrade our measurement capabilities.

Task Progress:
S. Biggar and P. Slater attended the MODIS calibration review on 18 July. Slater presented a description of the RSG's role in the calibration of MODIS with an emphasis on the vicarious calibration approach. Slater and K. Thome attended the MODIS Vicarious Calibration Workshop held at Wallops Island from August 7-10. Thome presented an overview of the vicarious calibration efforts of the RSG and Slater presented suggestions for joint preflight calibration campaigns. Slater met with J. Butler and D. Starr on August 23 to summarize some of the conclusions from the Vicarious Calibration Workshop and discuss how joint field campaigns might be organized. Biggar, Slater, and P. Spyak attended the MODIS Calibration Peer Review at SBRC from September 12-15 and provided comments on the review to B. Guenther.

A paper titled "Unified approach to pre- and in-flight satellite-sensor absolute radiometric calibration" authored by Slater, Biggar, Palmer and Thome was presented at the EUROPTO meeting in Paris and the written version was submitted to the proceedings of the SPIE. Revisions are now in progress for a version to be submitted to a peer-reviewed journal. The paper emphasizes the value of the sun in linking preflight and in-flight calibration of a sensor with the calibration of the radiometers used for vicarious calibration and the field validation of higher level data products. Slater discussed SeaWiFS plans with R. Santer (a co-investigator on our SeaWiFS grant) at the Universite du Littoral, near Calais. He also met with N. Fox of the NPL. Discussions included the subject of the contamination of small apertures used for calibration purposes. In addition to the calibration of SOLSTICE, this contamination problem relates to the screen used for the MODIS Solar Diffuser Stability Monitor and the partial-aperture, direct-solar calibrator on Landsat-7. Further discussions are to be held with MCST and SBRC.

Spyak reviewed Breault Research Organization's stray-light analysis on cloud-edge scatter and earth-scene integrated scatter for the nominal and improved surface scatter levels and various contamination levels. He discussed his findings with G. Godden of GSFC. Spyak also met with Godden at the MODIS Calibration Peer Review and the two concluded that, with respect to far-field scatter, a cleanliness level of 300 on the fore optics will dominate the system scatter. Spyak wrote a section for the MODIS Calibration Plan on transfer radiometer and round robin measurements and submitted it to Godden.

Biggar and B. Nelson continued work on the prototype and new version of the VNIR cross-calibration radiometers (CCR). They examined possible error sources in the prototype to ensure the new version does not have the same problems. Some of these errors will be solved with software modifications while others will require modifying the hardware. The two also searched for methods to reduce ground reference problems. Biggar ordered and received heater controllers for the new CCR and modified the radiometer software to monitor the six-inch spherical-integrating source. C. Burkhart changed the prototype CCR's housing. Biggar and Kingston worked on adding the automated filter wheel.

Spyak discussed with vendors the specifications for the cold filter, dewar window, and bandpass filters for the SWIR CCR and all three have been ordered. He received the second drawing package on the baffle/filter assembly from Cincinnati Electronics, reviewed it, and discussed changes with them. Spyak ordered and received the valve operator for the system's dewar. He and Burkhart discussed mechanical design concepts for the system and Spyak began the mechanical drawings for the radiometer. Burkhart began fabricating mechanical parts. Spyak and J. LaMarr started testing the lock-in amplifier using software developed by LaMarr. They discovered that a) we should not use the notch filters because they attenuate signals and the instruments become more nonlinear, b) we should not chop the signal near 60 and 120 Hz, c) we need to use longer time constants if we use a fast rolloff.

LaMarr measured the diffuse hemispherical reflectance of paint samples for the interior of the SWIR CCR, including Krylon ultra-flat black spray paint, ECP2200, Cat-a-lac black, Ebinol C, and anodized bead blasted aluminum. One interesting result is the anodized aluminum has a hemispherical reflectance of less than 3.5% from 300-700 nm, greater than 50% reflectance at 1000 nm, and nearly 75% at 1800 nm. LaMarr received several more anodized samples to study this effect further.

Spyak started characterizing the Optronic monochromator for SWIR CCR filter measurements. He received the cold filters and started measuring their spectral transmittance over the range from 275 - 6500 nm. He performed a spectral calibration for gratings 2 and 3 (about 900 - 3500 nm), and checked the calibration of grating 1 above 800 nm. All three gratings were brought to within specification (0.05% of the set wavelength). Spyak also performed stability tests over the range from 1020 - 4600 nm and concluded a two-hour warm-up time is required to achieve about 0.5% one-hour stability for wavelengths greater than about 1240 nm. At 1020 nm a warm-up time of 3 - 4 hours is necessary to achieve 0.5% one-hour stability.

LaMarr developed software to process the temperature and relative humidity data collected using the calibration laboratory sensors. He used this software to examine temperature and humidity data collected in the calibration laboratory to determine the effects of changes in these quantities on calibration measurements. Reference data were also collected while purging the system with dry nitrogen. The results have been compared to MODTRAN output for varying spectral resolution, spectral sampling, and relative humidity.

LaMarr found the germanium and pyroelectric detectors of our Optronic monochromator exhibited random fluctuations in the signal too large to attribute to noise. The problem was fixed by replacing a microprocessor in the unit. We received the InSb detector for the Optronic monochromator. Spyak is still awaiting the results from NIST of hemispherical-reflectance measurements of our Algoflon samples. Spyak received a ceramic glower for use as an infrared source. Spyak and LaMarr began tests to study the feasibility of creating 2 foot square Algoflon samples for calibration purposes. Several "sub-standard" small Algoflon samples were created and measured. The reason for this was the belief that it will be more difficult to create a "perfect" 2-foot square sample. In all cases, the "sub-standard" samples are as lambertian as the "good" samples. LaMarr developed software to compute reflectance-panel coefficients from raw calibration files.

Burkhart machined a fixture for B. Crowther which will be used for preliminary machining tests of the Spectralon material Crowther will use for the diffuse-to-global meter. Crowther began work on the LiCor control software. Burkhart and Crowther examined the spheres supplied by Labsphere for the diffuse-to-global meter. Several blemishes were found where rust and oil were absorbed by the Spectralon at the attachment points between the hemispheres which make up the spheres. These blemishes are far enough away from the internal spherical surface that they should not be a problem. Another problem is that there are visible seams between the two hemispheres. Crowther gathered information on quartz and glass domes to be used on the sphere during dusty or otherwise marginal weather conditions. Burkhart grey-anodized a test plate for Crowther to test the reflectance of this material for evaluating its use in the diffuse-to-global meter.

Brownlee examined light levels for the BRF meter and found they are similar for the system's upper three wavelength bands but the UV band is approximately an order of magnitude smaller. She developed a macro within PMIS image software package to open stored image files, and calculate the minimum, maximum, average and standard deviation of a 10 x 10 pixel region centered on a 50% reference panel. Examination of BRF data show some of the image files are shifted by 11 pixels which is handled in the processing. She investigated methods for rotating and translating the camera for the system's flat-field calibration and determined our 40-inch spherical-integrating source is spatially-non-uniform but repeatable. Brownlee investigated measuring the camera's spectral response with the Optronic monochromator and designed the filter holder for the BRF-meter's camera system to hold up to two filters. She continued investigating calibration methodology and identifying necessary equipment. Using IDL, Brownlee began developing BRF model data based on the 1995-04-01 White Sands data to use for a BRF retrieval sensitivity study. Burkhart machined a set of filter adaptor rings for the system.

Brownlee investigated beam traps and black surfaces for testing stray light in the camera and ordered a beam trap and a beam dump. She began investigating replacing the camera window with an absorption filter. The current window is a 2-inch diameter, 1/8-inch thick, fused silica. She is considering a correction filter which is more transparent in the UV than at longer wavelengths. She talked to J. Palmer of OSC regarding the replacement of the camera's exit window with a neutral density filter. He has the facilities for pumping down the camera once the window is replaced. Brownlee decided to use neutral density filters to determine window transmittance requirements rather than extrapolating digital counts measured at shorter exposure times and purchased two Wratten filters for this purpose. She determined the camera head's shutter speed is not repeatable at 10 ms but is at 150 ms, had the shutter replaced by one which is five times faster, and collected data in the blacklab to test its repeatability. Measurements were made to determine maximum light levels with the new shutter. The new shutter allows Brownlee to place a filter before the exit window rather than the more complicated case of replacing the exit window.

Gustafson continued work on the cross-calibration between Landsat-5 TM and SPOT-3 HRV using the October 8 and 9, 1994 data from White Sands Missile Range. Using ASD data of Chuck Site from the April White Sands trip she found the difference between the reflectance at the center wavelengths of overlapping bands for the two sensors to be largest for bands 2 of TM and 1 of HRV (5%). The other two sets of wavelengths (bands 3 of TM and 2 of HRV, and bands 4 of TM
and 3 of HRV) were within 1% of each other. Thome determined that BRF effects between the two data sets should be less than 1% based on April, 1994 BRF data. Gustafson did the cross-calibration using the computed reflectance-based calibration of HRV from the October 9 data as the reference. From these results, she computed the surface reflectance for several selected target areas. She then used these reflectances and the October 8 atmospheric data to compute the calibration coefficients for corresponding bands of TM. These cross-calibration values were compared to the calibration coefficients for TM based on the reflectance-based calibration of October 8. Using a part of Chuck Site as a target, Gustafson found results consistent with the surface reflectance differences between bands. That is, the difference between the ground-based calibration coefficients and the cross-calibration-based coefficients are 0.3-4.3% with the largest value being for TM-band 2 and HRV-band 1. She also found the results to be site dependent with darker targets not as good as brighter targets. Gustafson found several sites for which increasing the size of the target from 90X90 meters to 270X270 meters has little effect on the results.

Gustafson ordered a new, longer optical fiber for our ASD FieldSpec FR. She has also scheduled the spectroradiometer to have the second SWIR grating upgraded, received an update to the system's data collection program, and also received a data collection program tailored for the VNIR. This last software will allow us to better examine the temporal variability of the system. Gustafson also modified her ASD processing software used to convert the data to a format suitable for our surface reflectance retrieval. She provided Thome with the formatted ASD data from the Ivanpah Playa data collection. Gustafson also collected ASD data of several soil samples for A. Batchily of A. Huete's group at the University of Arizona.

R. Parada began reducing the AVIRIS / HYDICE aircraft data. Parada discussed these results with Santer while he visited the group in July. Parada attended the Bio-Optical Oceanography summer course at Friday Harbor Labs in Washington.

Thome modified the Gauss-Seidel radiative transfer code to operate in hyperspectral mode. He modified Biggar's optical depth determination code to also operate in hyperspectral mode and to write the needed input file to the hyperspectral radiative transfer code. Thome also modified the surface reflectance retrieval code to handle the ASD data from Ivanpah Playa and completed processing the reflectance-based calibration of HYDICE using the recently developed hyperspectral code and the panel calibration data obtained from Spyak.

Thome sent comments to G. Geller of JPL regarding ASTER Level-1 quality assessment documentation. Thome sent R. Barnes of SeaWiFS MODTRAN transmittance output to study the effect of oxygen absorption in SeaWiFS processing. Thome worked with A. Murray of JPL to set up the runs for developing the prototype look-up table for the ASTER atmospheric correction.

Crowther, Recker, and Thome worked on sending the 10-channel solar radiometer to Hawaii where Crowther collected data in support of TIMS overflights. While in Hawaii, Crowther made two attempts to collect Langley data on Mauna Kea but was unsuccessful due to weather. Plans were made for an early October trip to White Sands to calibrate SPOT-2 and -3. Thome completed a solar-radiation-based calibration of our MMR using data collected at Lake Tahoe last June.

Future work:
Slater will write a section of the MODIS Calibration Plan on vicarious calibration. The Remote Sensing Group will host a meeting of several ASTER team members on October 17 and 18 to discuss plans for joint calibration and validation campaigns. Butler and Starr have been invited. B. Guenther and H. Parks are planning to meet with us on October 25 and 26 to discuss the preflight calibration of MODIS using the solar diffuser and either the sun and/or artificial light sources. Slater and Thome will attend the ASTER Science Team meeting November 13-17 in Tokyo. Biggar will attend the MODIS Science Team meeting held that same week in Washington, D. C. Spyak will continue his work on the SWIR transfer radiometer. He also hopes to receive the results of NIST comparisons between Halon and Algoflon samples.

Brownlee will contact B. Neville of CCRS about their methods for flat-field calibration. She will investigate setups for calibration experiments to determine requirements for hardware. She will continue examining the spatial uniformity of the 40-inch SIS by positioning the camera inside the sphere and noting changes in response as it is moved.

Gustafson will test the ASD by comparing filtered-radiometer reflectance data to that from the ASD. She will also begin characterizing the ASD in the calibration laboratory based on methods used in a recently published paper.